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Integrated Energy Systems with Multiple Energy Carriers

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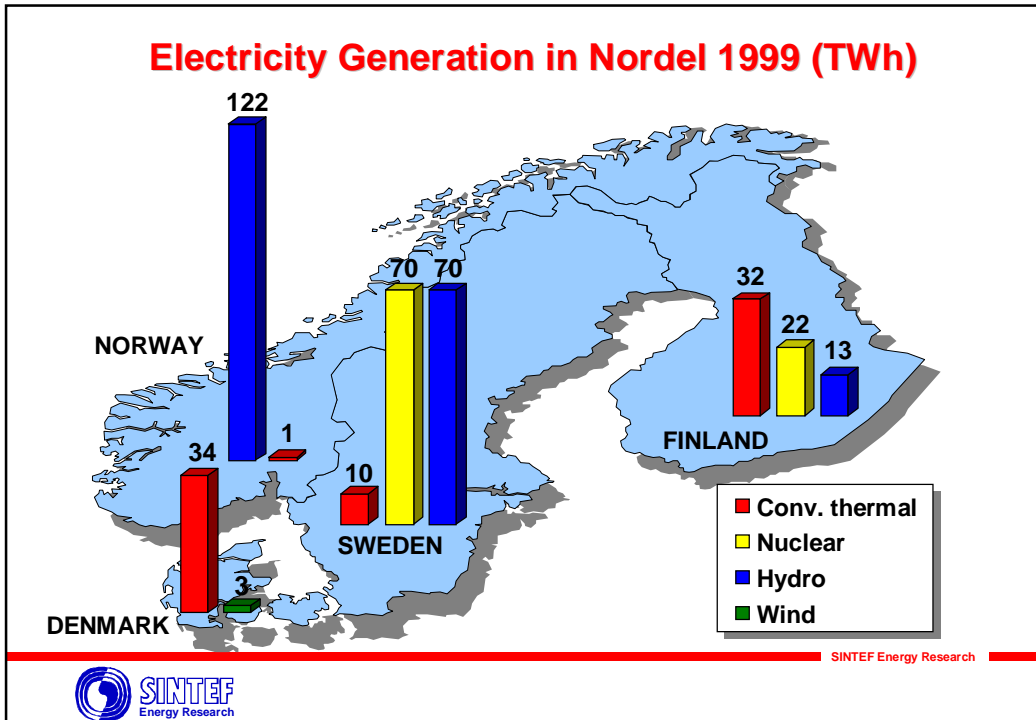
Integrated Energy Systems with Multiple Energy Carriers Overview

- Introduction - The Energy System
- Concept: Integration of new distributed energy sources
- Interface issues
- The Norwegian Power Quality Project
- Tool: Analysis of systems with multiple energy carriers

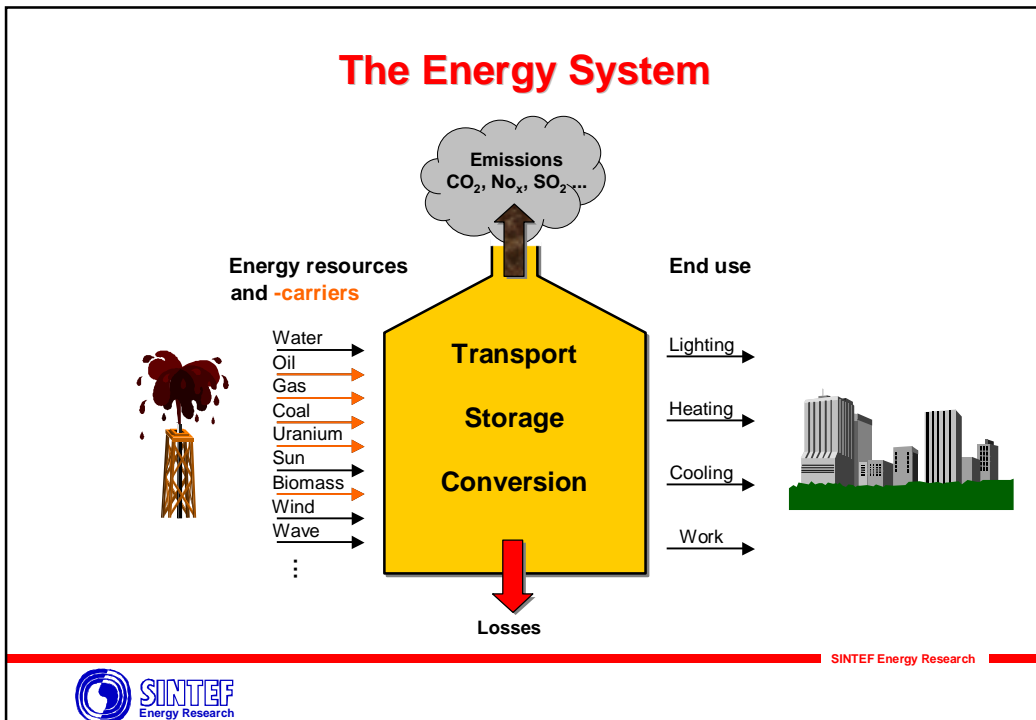


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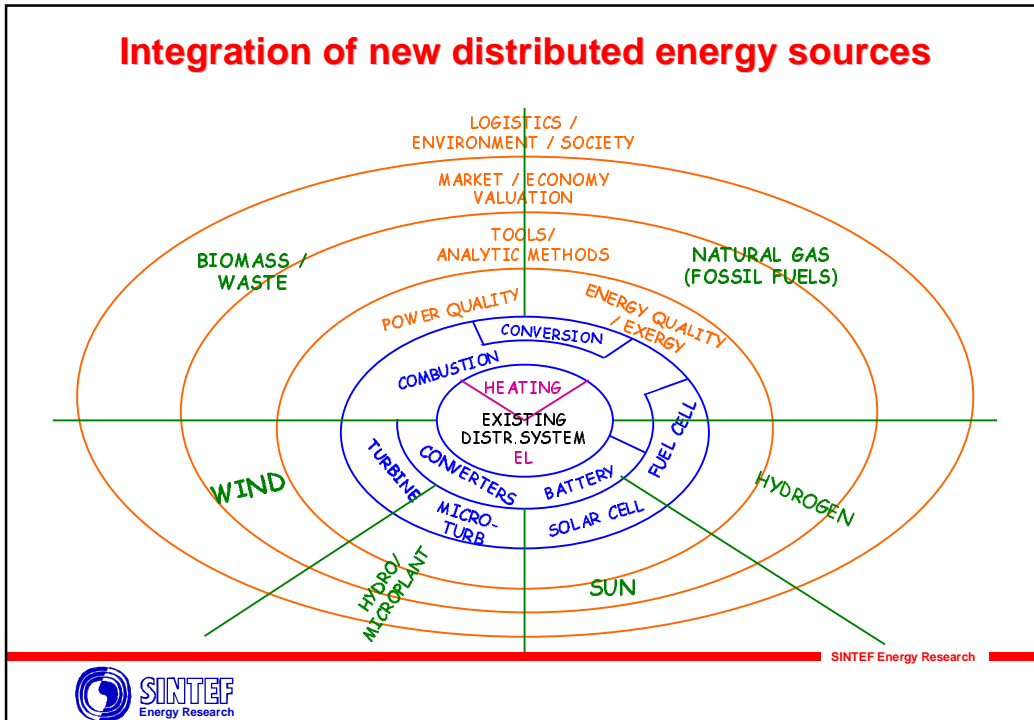
Electricity Generation in Nordel 1999 (TWh)



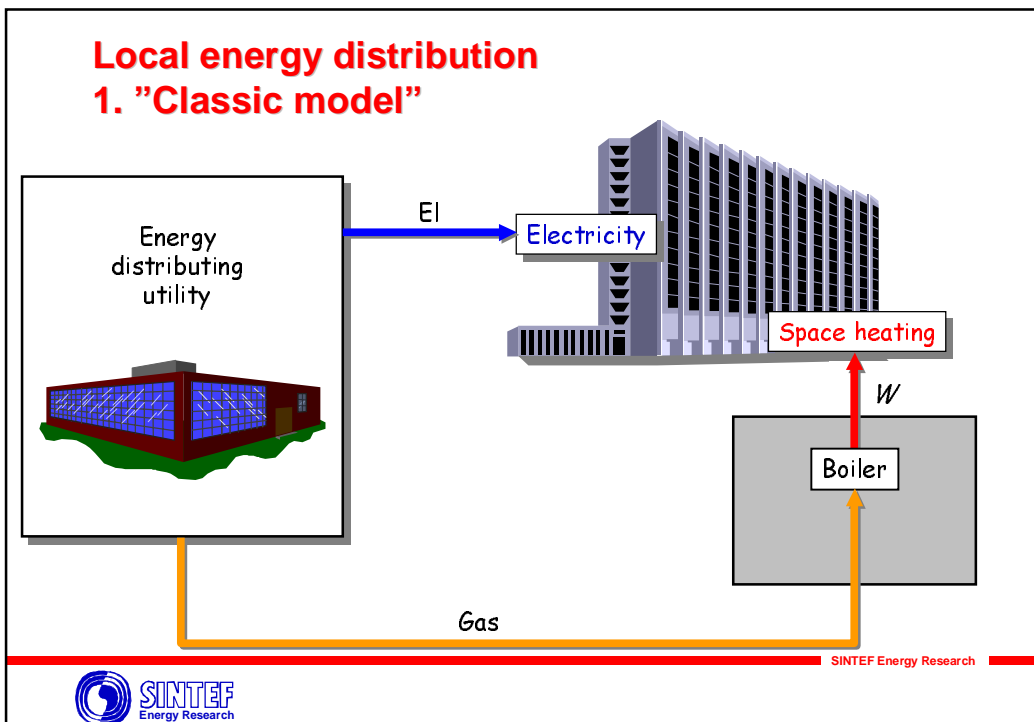
The Energy System



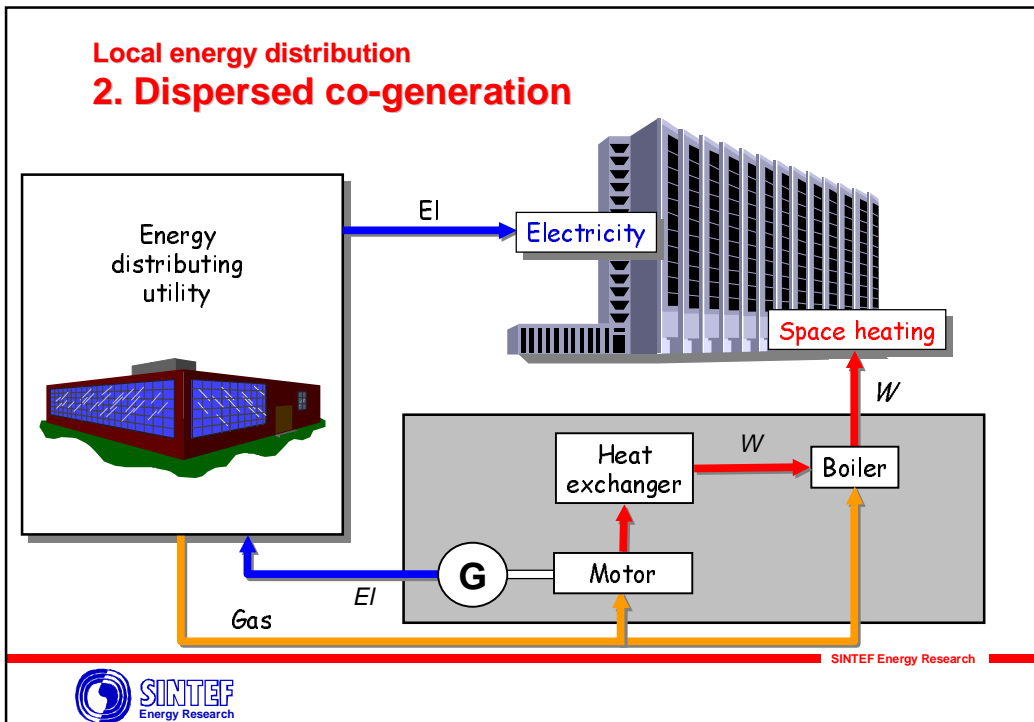
Integration of new distributed energy sources



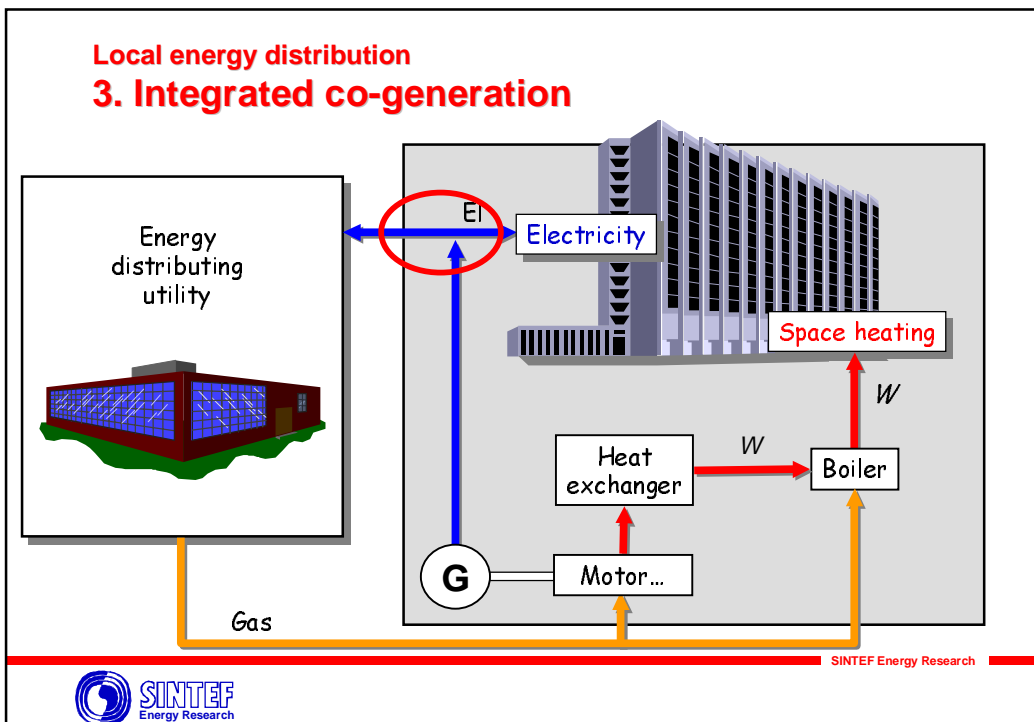
Local energy distribution 1. "Classic model"



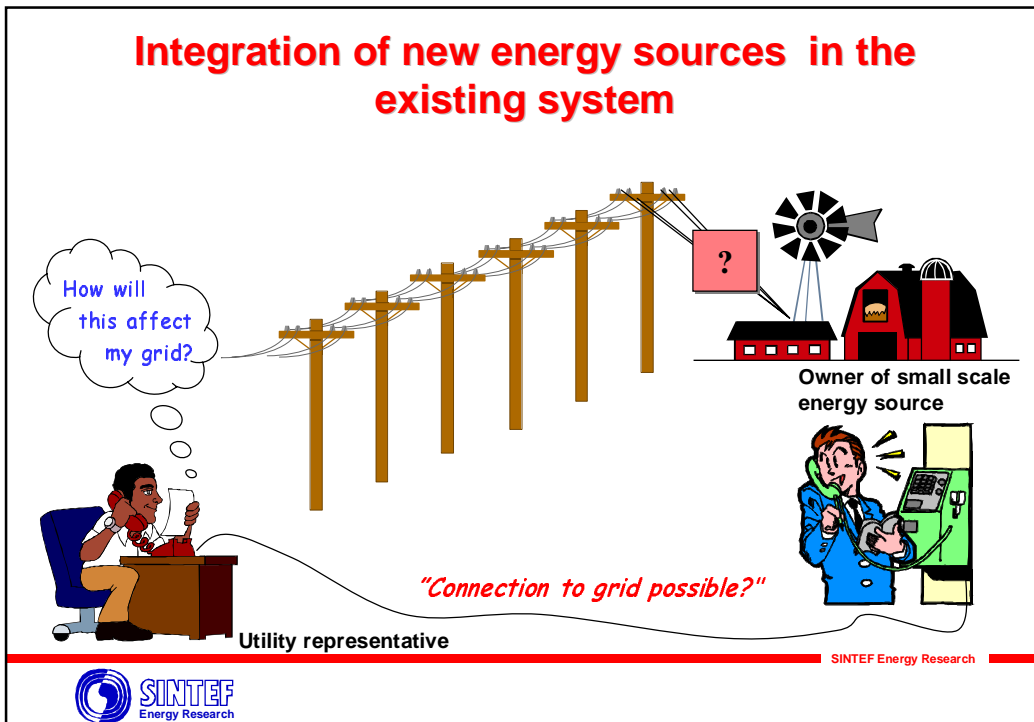
Local energy distribution 2. Dispersed co-generation



Local energy distribution 3. Integrated co-generation



Integration of new energy sources in the existing system



Design of customer gateway

Type and size of customer

- domestic
- farming / greenhouse
- industrial
- public service (office, school etc)
- shopping
-

Class of generation unit

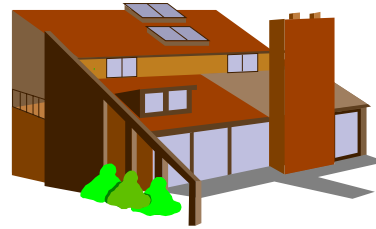
- **synchronously rotating machinery**
 - gas turbine, stirling engine, steam turbine etc
- **induction generator**
 - wind turbine, micro-hydro
- **piston engines**
 - diesel engine, gas engine
- **DC source**
 - solar cell, fuel cell

What are the customer and utility needs?

- metering (2-way)
- protection (2-way)
- PQ Conditioning (2-way)
- remote control & monitoring
- circuit breaker control
- commercial communication possibilities (phone, cable TV, internet)
- energy and power management (2-way)

"House of tomorrow"

- Central heat storage system
- Micro-cogeneration unit
- Thermal solar cells
- Gas fuelled heat pump
- Hot fill washing and dish washing machines
- Gas fuelled dryer, stove and fireplace
- PEX-based indoor gas piping with flexible gas outlets e.g. for outdoor grilling
- Heat exchangers / regeneration



Source: Gasunie Research, NL



"House of tomorrow"

Customer – Utility relationship

- *Is it realistic to assume that a single customer/houseowner can design, invest and maintain the complex energy systems of the future in his own house?*
- ✓ The Customer buys *Comfort* on a contract of sufficient time frame
 - desired room temperature
 - no. of residents, no. of bathrooms/showers etc.
 - stoves, washing machines, fireplace etc.
 - ⇒ *The customer pays only a monthly Energy bill*
- ✓ The Energy utility *designs, invests, operate and maintain* the customer's energy system
 - ⇒ *Possible to optimize the system in a wider context (house, area, region...)*
 - ⇒ *Need for advanced tools to optimize such customer relations*



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The Norwegian Power Quality project 1993 - 2001

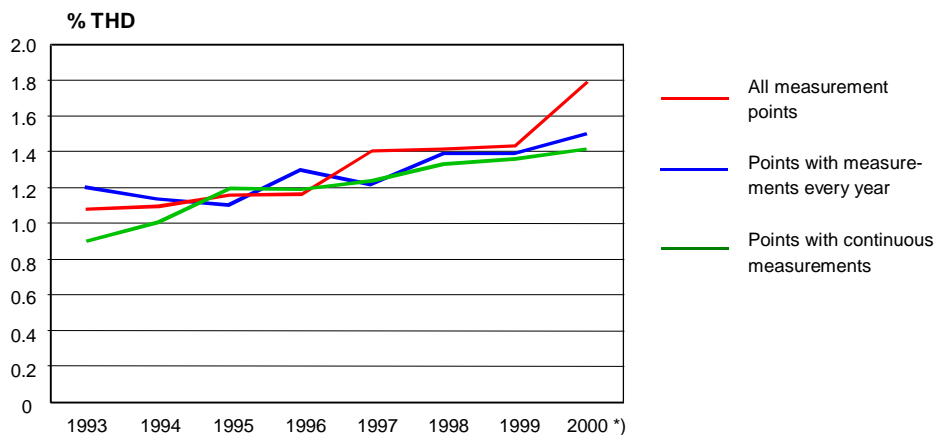
Activities:

- ✓ Measuring methods and instrumentation
- ✓ Measurement campaign and national database (including analysis of data)
- ✓ Solving practical PQ-problems
- ✓ Power electronics related to PQ
- ✓ Correlation between lightning activity and PQ
- ✓ Individual contracts regarding PQ between customers and utilities

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Power Quality in the Norwegian Network Trends for Total Harmonic Distortion



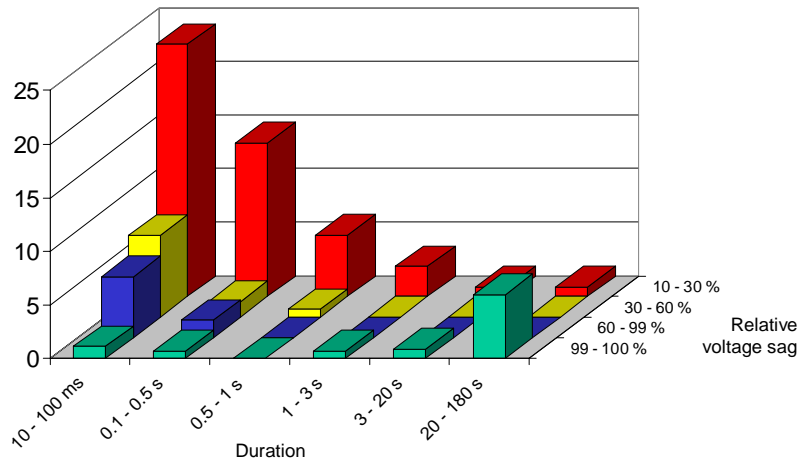
*) the data covers only the first half of 2000

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Power Quality in the Norwegian Network Voltage sags

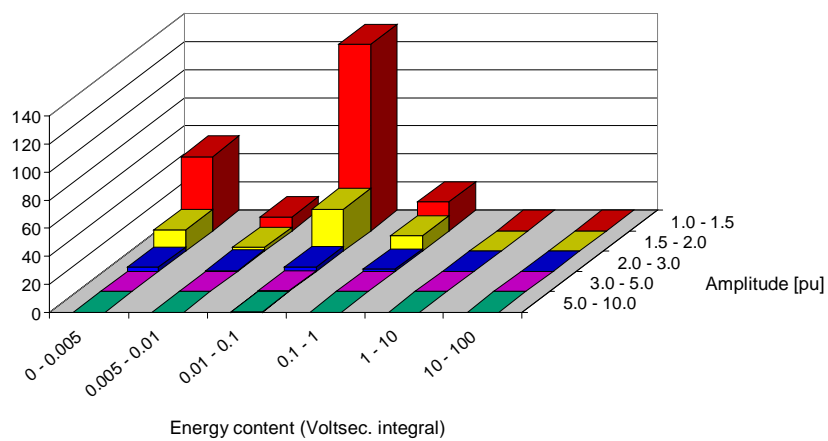
Mean annual number of voltage sags for low voltage networks (230-400 V)



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Power Quality in the Norwegian Network Transient overvoltages

Mean annual number of transients in low voltage networks (230-400 kV)



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Power Quality in the Norwegian Network Voltage sags

Comparison of mean annual numbers
for high voltage distribution networks (11-22 kV)

Country	No. of voltage sags	No of short interruptions	Total no. of events
USA	66.2	8.5	74.6
Norway	91.9	18.0	109.8
Italy	279.8	58.2	338.0



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Analysis of energy distribution systems with multiple energy carriers

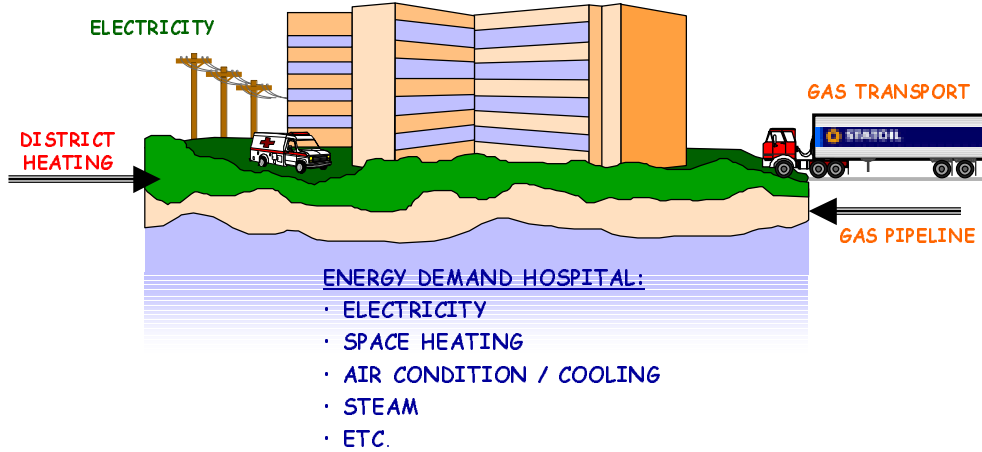
Methodology

- ➔ **AIM: develop a flexible tool for analysis of complex energy systems with multiple energy carriers**
- ✓ **generate system model with standard modules for transport channels, energy conversion processes and storage capacity**
- ✓ **connection to superior system model through simple and uniform set of linear variables**
- ✓ **superior system analysis in a general network model**
- ✓ **attributes like aesthetics, noise, impact on nature etc included through a new variable "Energy Quality"**



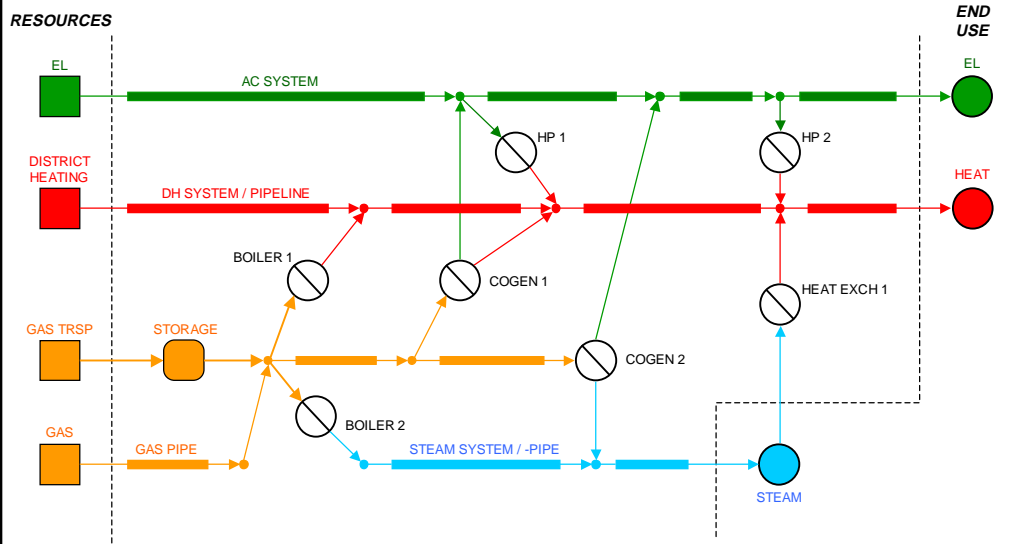
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Case A: Energy supply to hospital



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System model for hospital



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